NVESTIGATING ALTERNATIVE 'GREEN' PRIMARY EXPLOSIVES

John Hirlinger
US Army ARDEC
Mounted & Dismounted Infantry Munitions Group
Armament Engineering & Technology Center
973-724-6498
jhirling@pica.army.mil

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Program Goal

- Develop environmentally friendly alternatives to replace Lead and other Heavy Metals, Volatile Organic Compounds (VOCs), & Carcinogens while maintaining ammunition safety and performance requirements

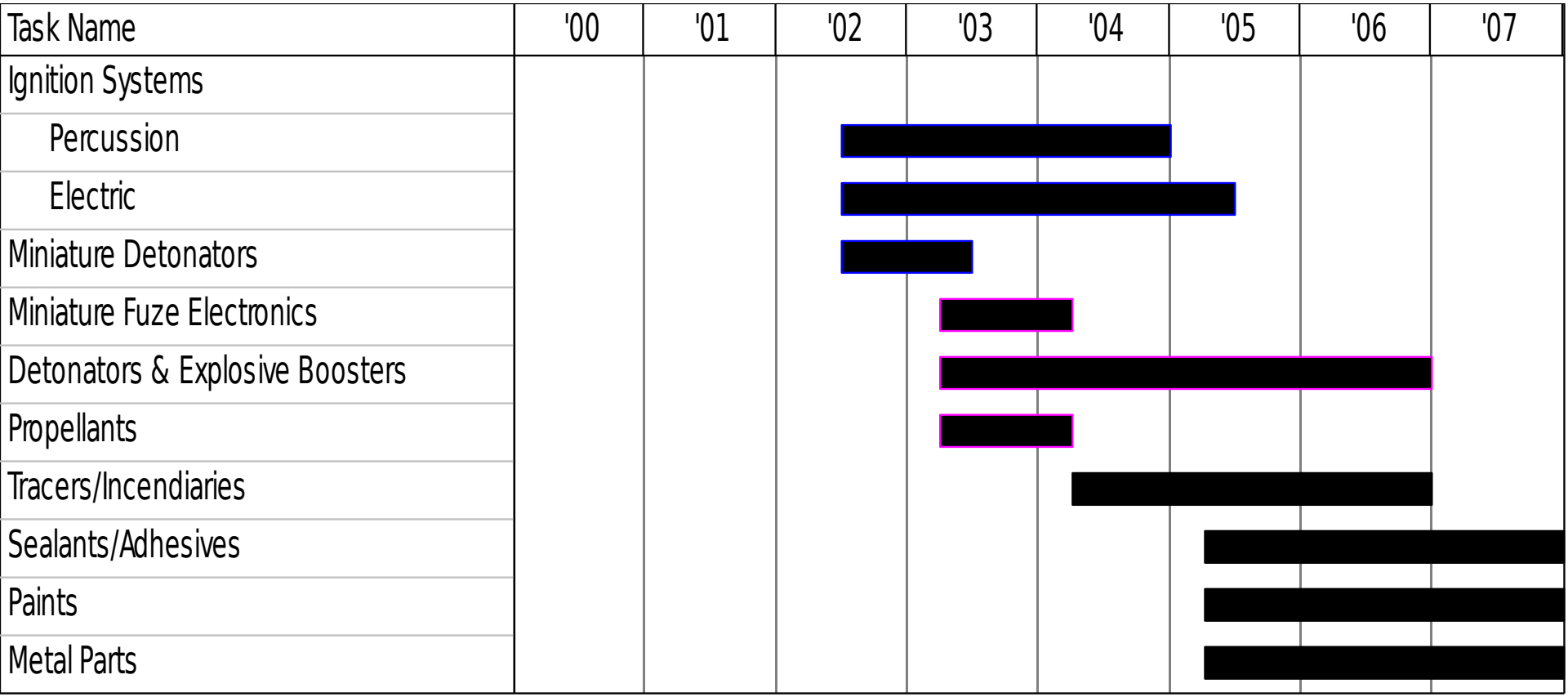
ENVIRONMENTALLY UNFRIENDLY COMPOUNDS USED IN MEDIUM CALIBER MUNITIONS

HEAVY METALS	VOCs	SUSPECTED CARCINOGENS
Antimony Sulfide	2- Butoxyethanol	Methylene Chloride
Barium Nitrate	N-methyl 2-Pyrrolidone	Diphenylamine
Depleted Uranium	Ethyl Alcohol	Dibutylphthalate
Lead Azide	Ethyl Benzene	Nitroglycerine
Lead Styphnate	Methyl Isobutyl Ketone	
Cadmium	Xylene	
Nickel Acetate	Toluene	
Chromium VII	Loctite	
Lead	Formaldehyde	

Sponsor/Customer

- Strategic Environmental Research & Development Program (SERDP)
  - Dept of Defense's (DoD) corporate environmental R&D activity
    - Partnered with Dept of Energy (DoE) + Environmental Protection Agency (EPA)
  - Identifies & develops environmental technologies directly related to defense mission accomplishment
  - Providing funding
- SERDP Web Site – www.serdp.org

Multi-Year Priority Sequencing of Green Activities & Program Funding



FY02 Start

FY03 Start

Planned

Green Medium Caliber Munitions Program Organization

* Denotes SEED Program

Environmental Focus

- ✓ Heavy Metal Free Primers (Percussion/Electric)
- ✓ Lead Free Detonators/Initiators
- Thermo-Plastic Elastomer (TPE) Propellants
- Organic Super capacitors

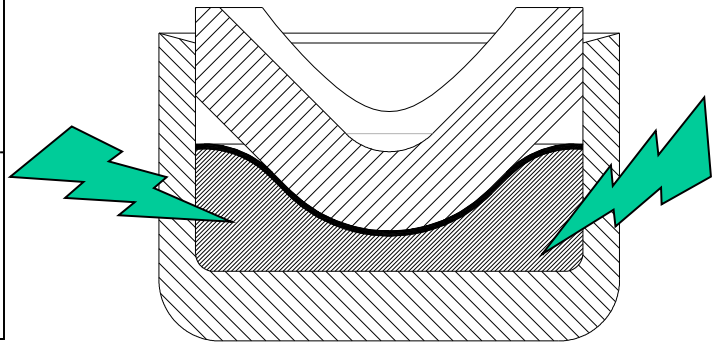
PRIMERS

Conventional Primer Composition

Lead Styphnate
Barium Nitrate
Antimony Sulfide
Aluminum
PETN
Tetracene

YIELDS

Carbon Monoxide
Nitrogen
Carbon Dioxide
Water
Alumina
Antimony Sulfide
Barium Oxide
Sulfur Dioxide
Hydrogen
Lead
Barium Hydroxide
Sulfer Monoxide
Lead Sulfide
...and other traces



Green Primer Composition

MIC + ADDITIVES
Aluminum
Molybdenum Trioxide
Ethyl Cellulose
Calcium Resinate
PETN
BTATZ

YIELDS

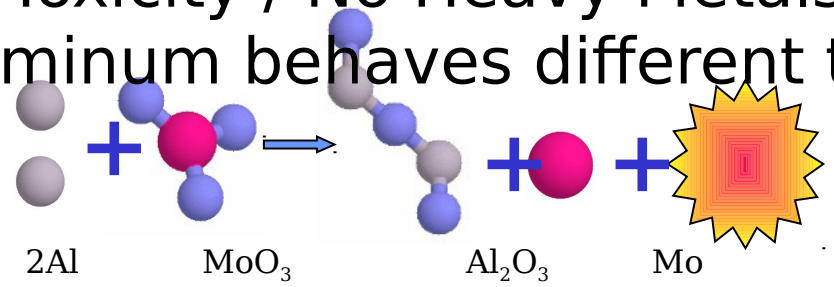
Hydrogen
Carbon Monoxide
Carbon
Aluminum
Alumina
Molybdenum
Aluminum Oxide
Aluminum Nitride
...and other traces

Environmentally acceptable medium caliber percussion primer yields no toxic by-products in comparison to conventional primer compositions

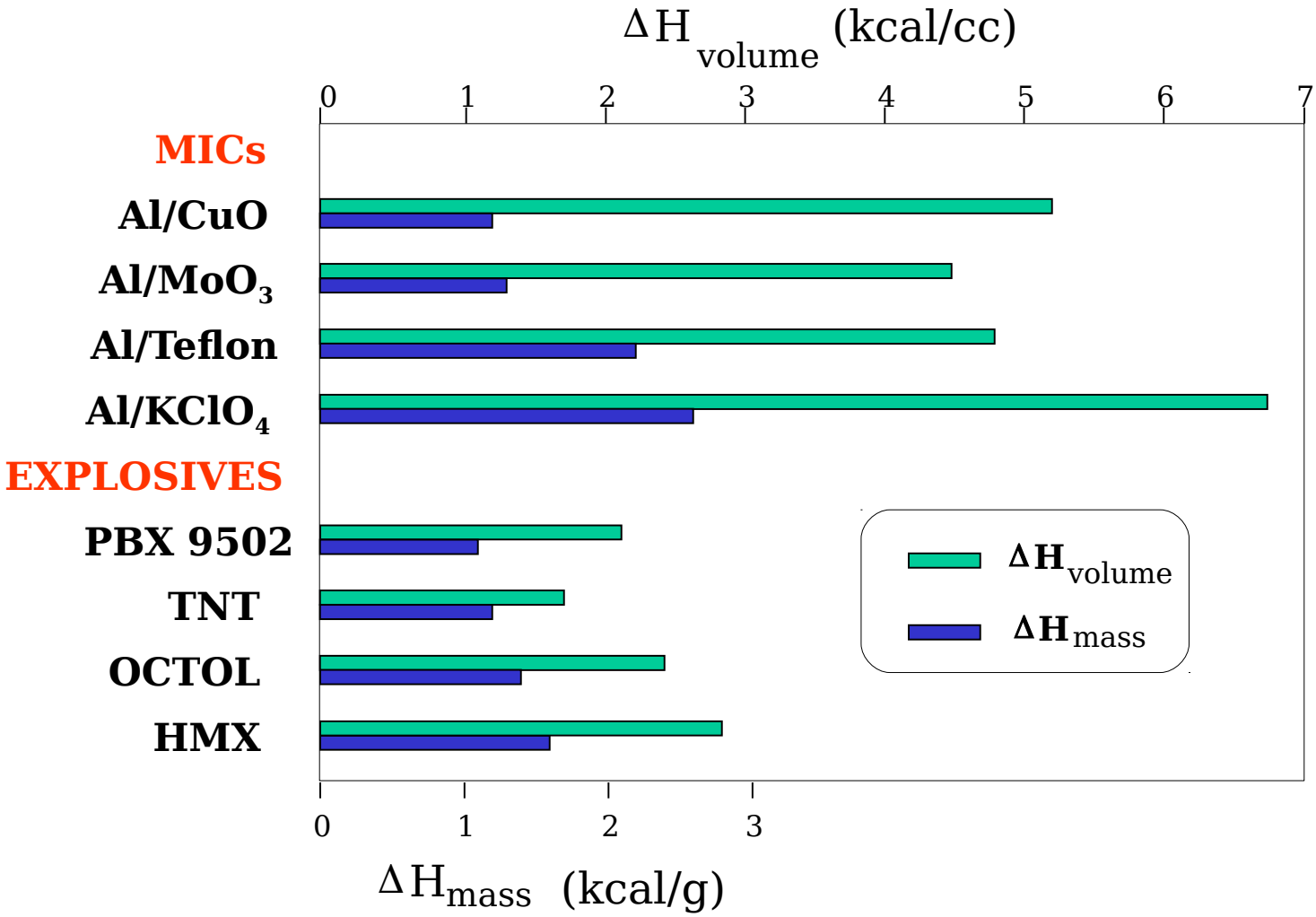
WHAT's MIC ?

METASTABLE INTERMOLECULAR COMPOSITES

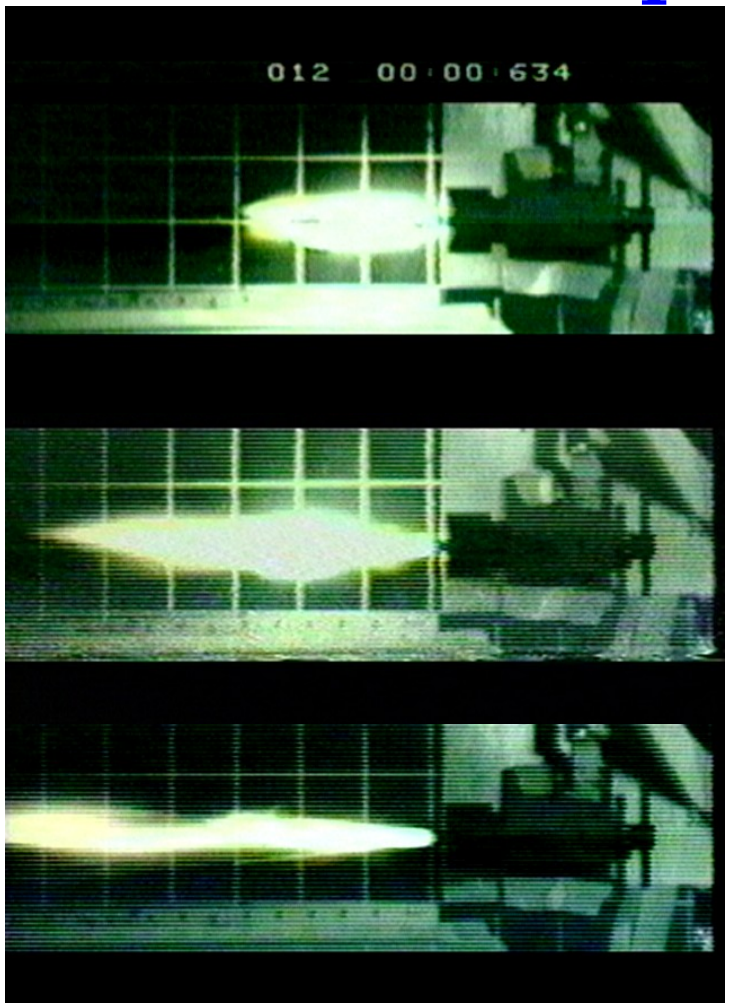
Super-thermite mixture of Aluminum + Oxidizer
Applying Nano-Technology (nanometer sized particles)
Reactant clusters in atomic-scale proximity
Tailored Energetic
Tunable Ignition
Reduced Toxicity / No Heavy Metals
Nano Aluminum behaves different than micron size

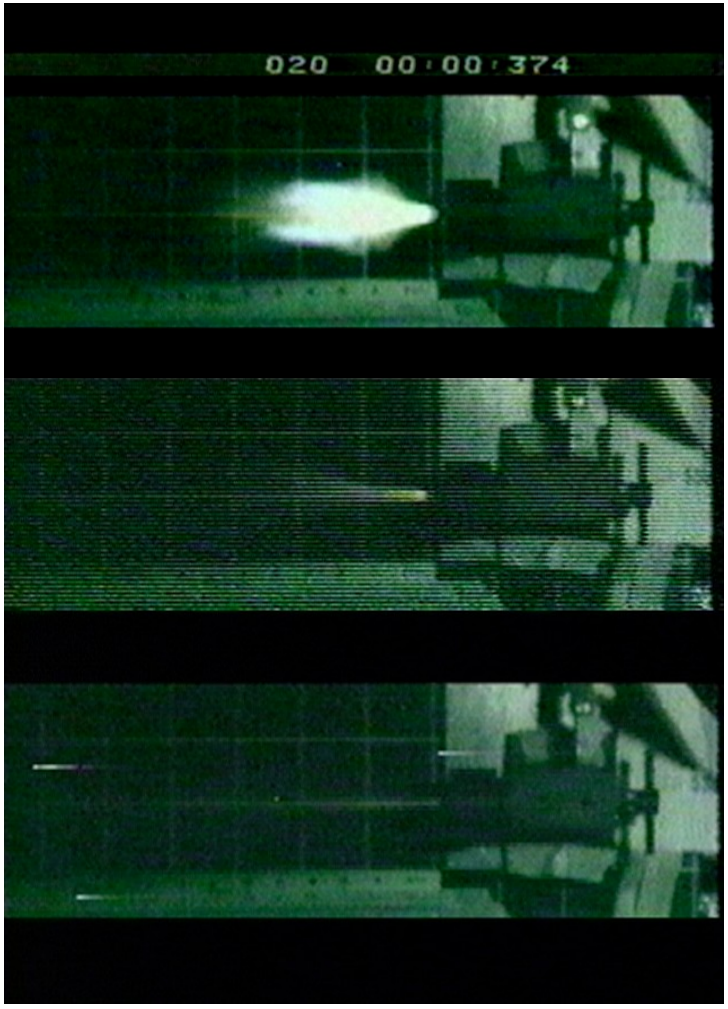


MICs RELEASE MORE ENERGY THAN HIGH EXPLOSIVES



Primer Output
Flame Test Comparisons For Primers

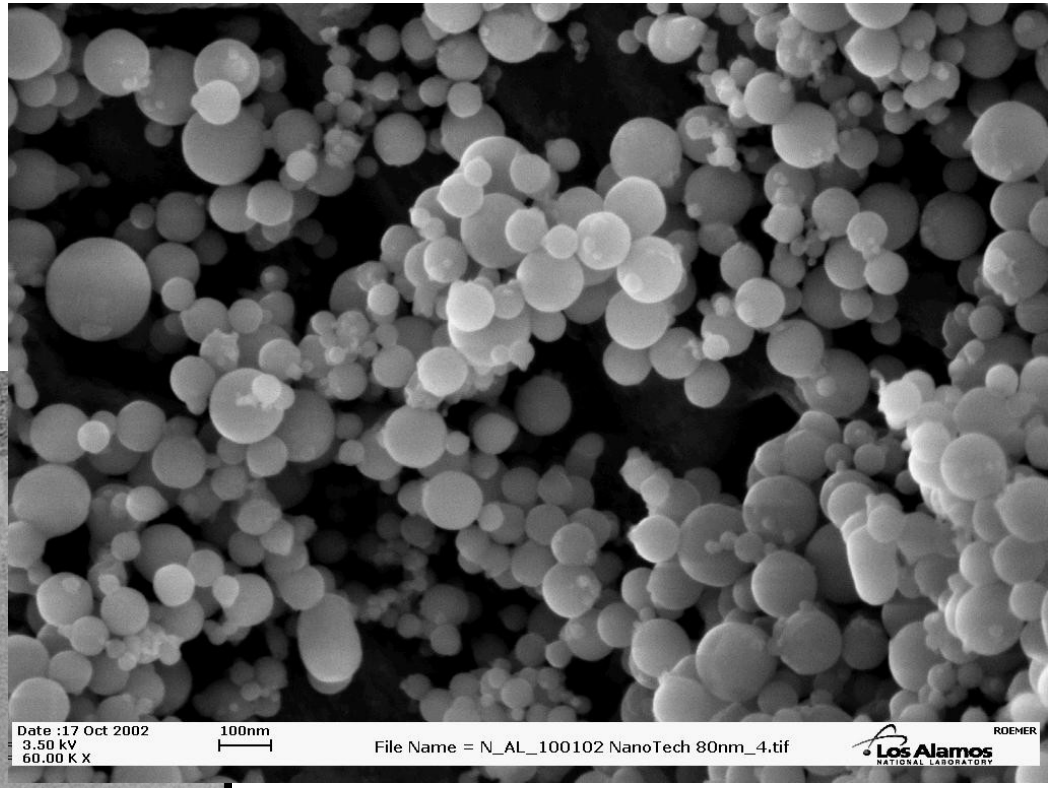


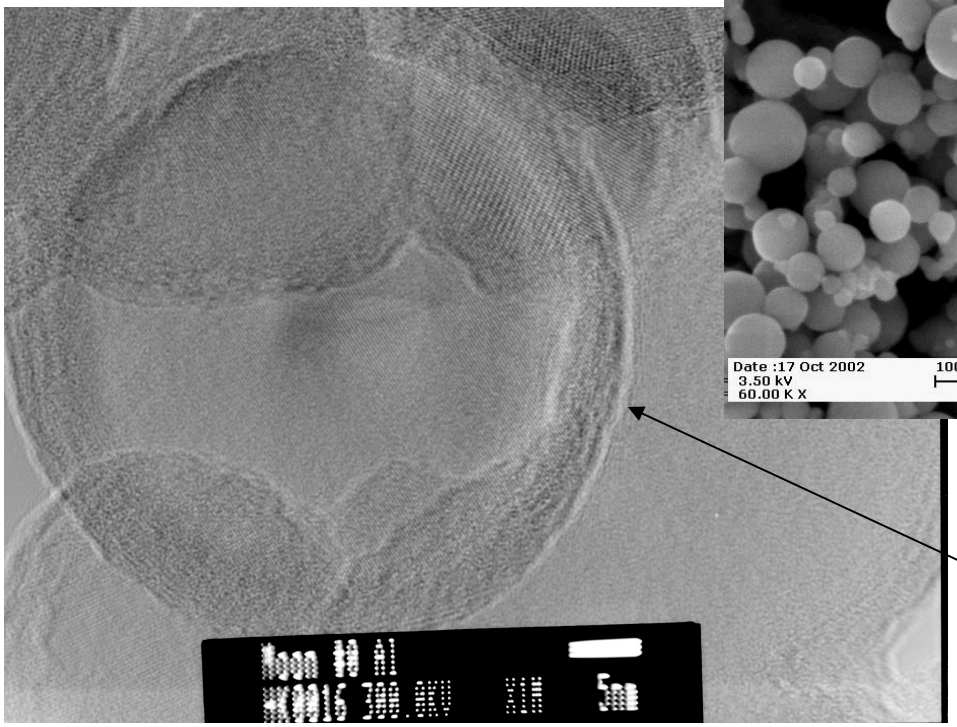


Al/MoO_3-based MIC Primer

Standard PVU-1A Primer (Lead Styph

Transmission Electron Microscopy (TEM) of MIC East Nano Aluminum Powder





2.5 nm thick Al_2O_3 passivation layer

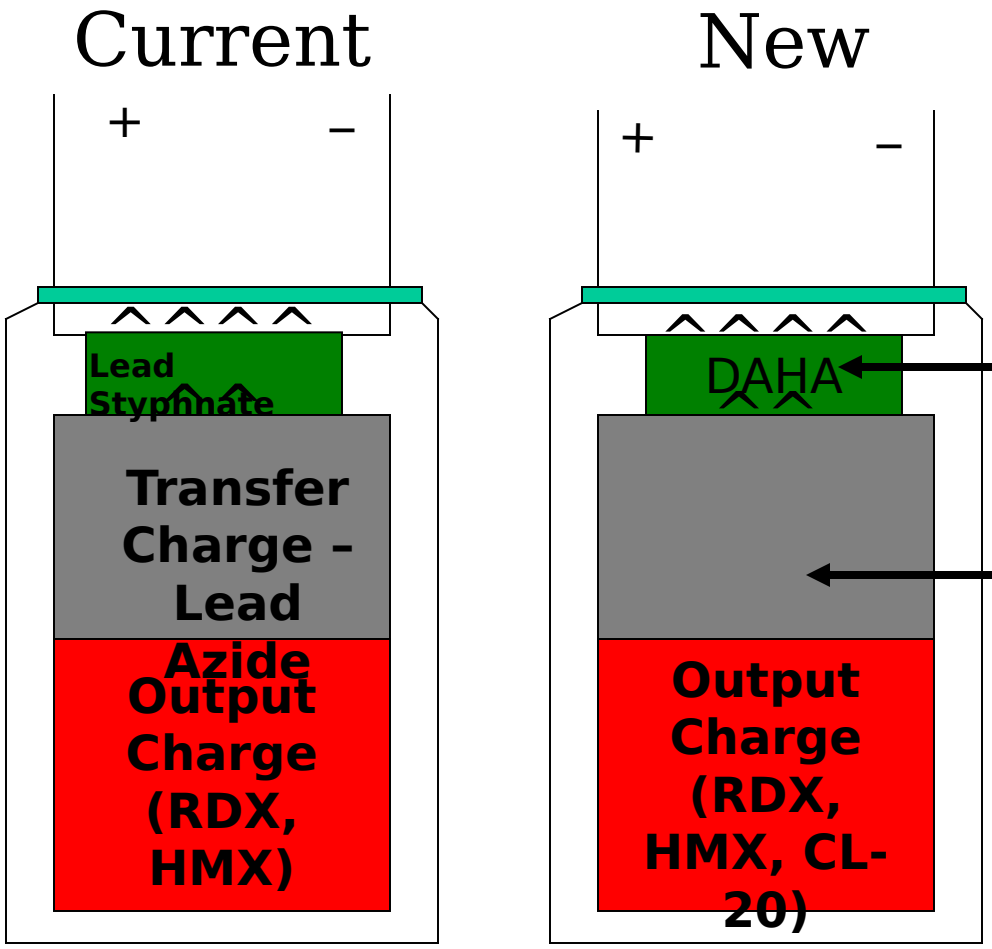
Percussion Primer Formulations Tested

- **M793 TP-T Ballistic Test Series (Mar 04)**
  - M115 w/o booster
  - MIC +10 w/o booster
  - MIC +10 w/ booster pellet ($BKNO_3$)
  - MIC w/ booster ($BKNO_3$)

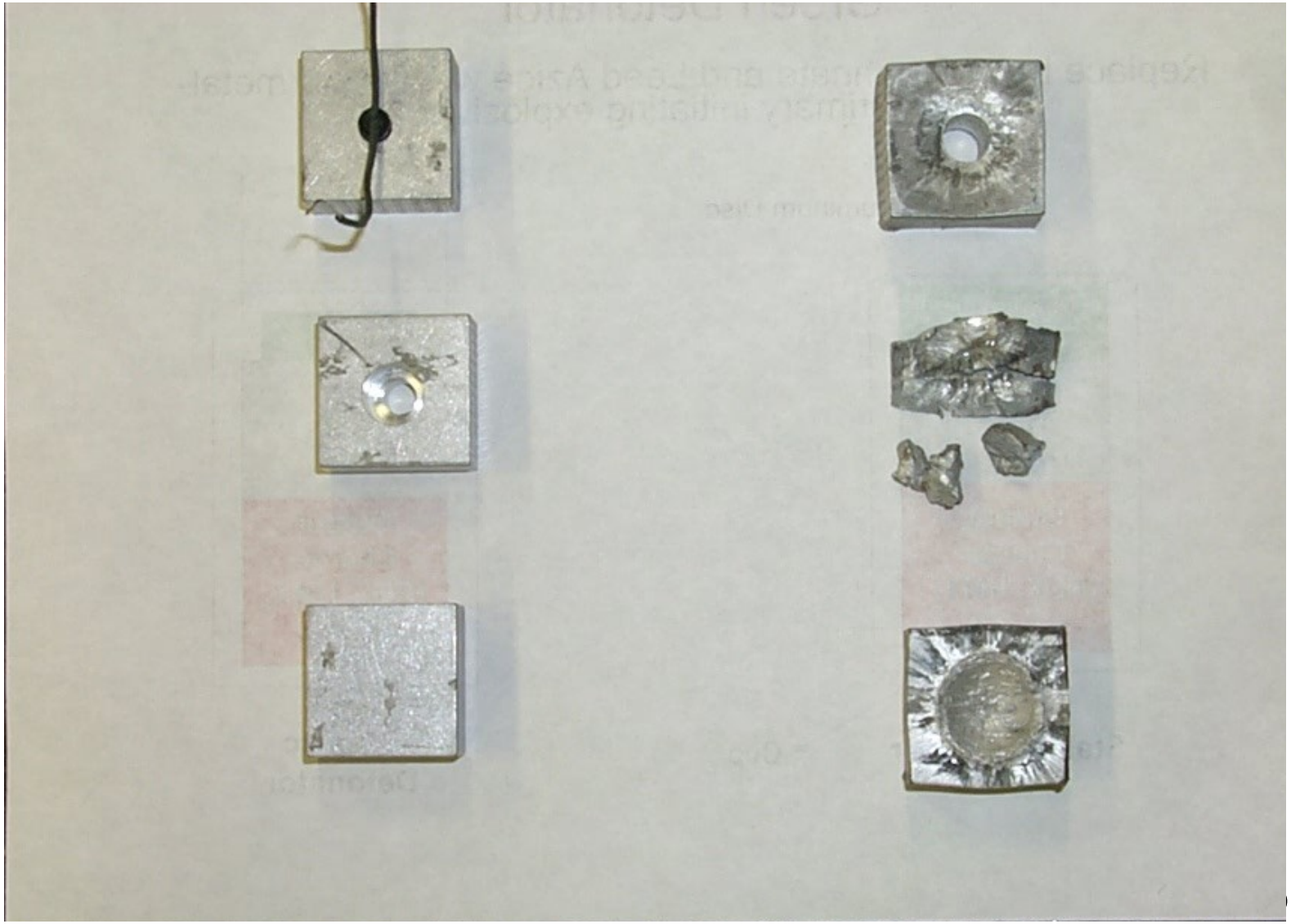
Primer	Mid Case Chamber Press (psi) Req't < 72,000 psi	Muzzle Velocity (m/s) Req't = 1,100 m/s	Action Time (msec) Req't < 6.0 msec
Standard M115 (7 rounds)	64,443	1,100	**4.225**
MIC + 10 w/o booster (5 rounds)	61,772	1,100	**102.328**
MIC + 10 w/ booster (5 rounds)	61,210	1,107	**4.632**
MIC w/ booster (4 rounds)	59,968	1,107	**5.026**

Acceptable action times!

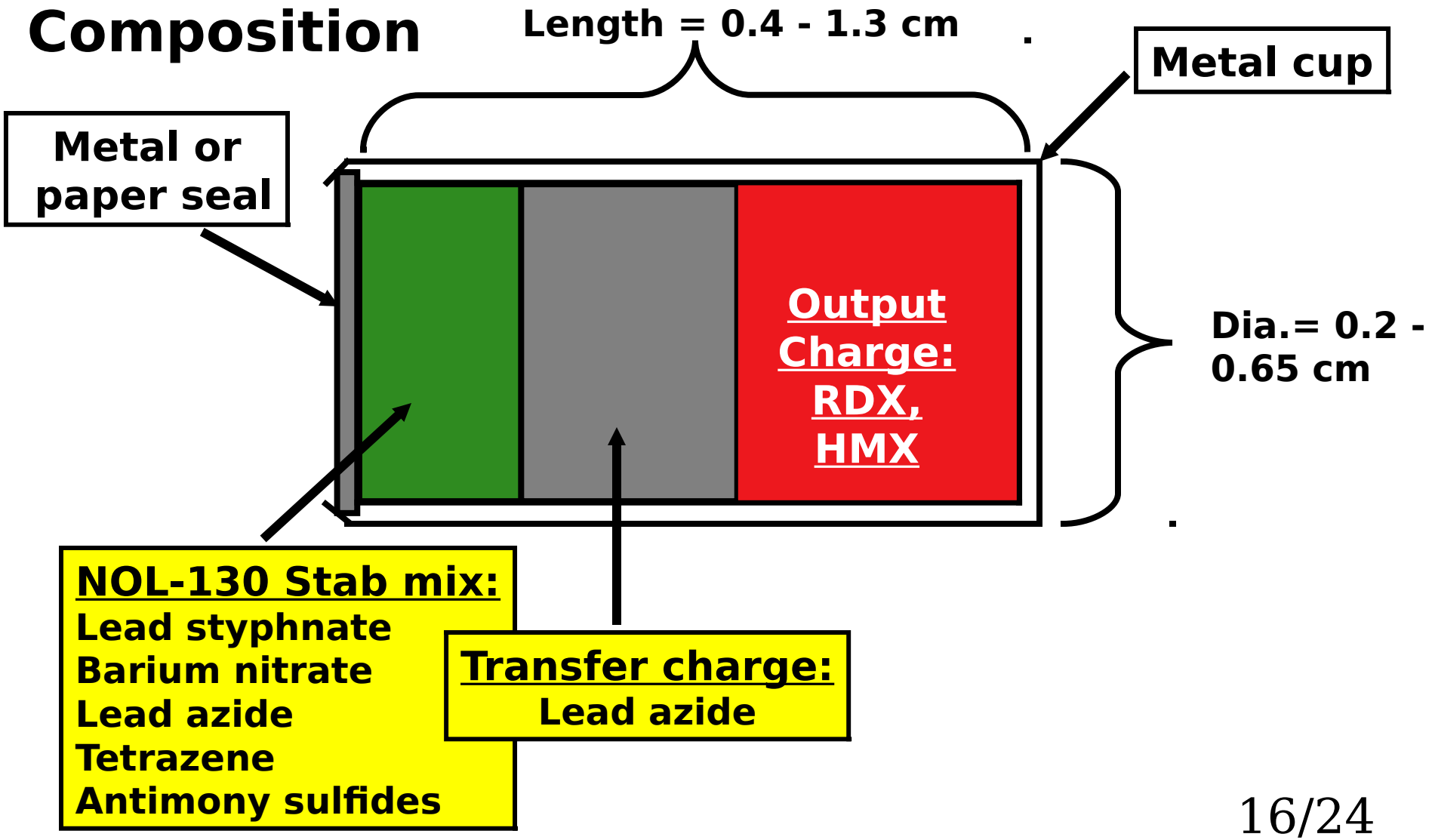
Electric Detonators



STATIC FIRING RESULTS



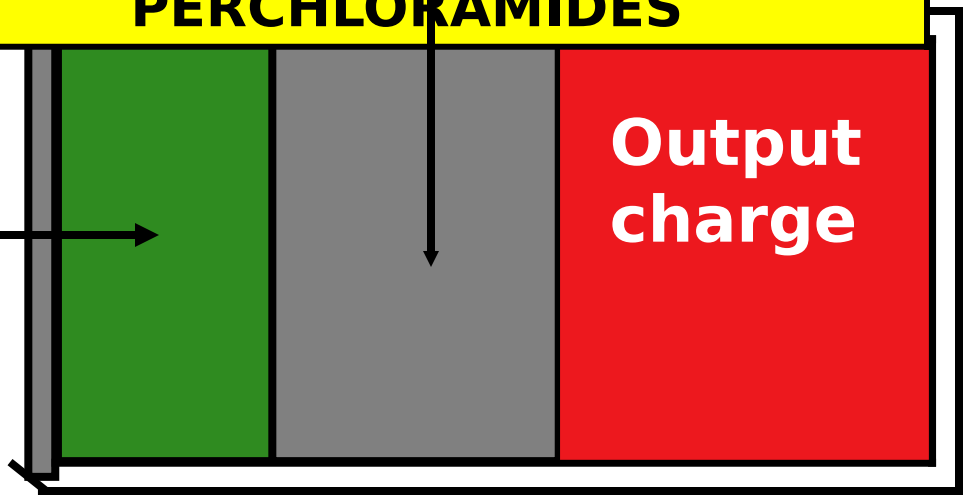
Current Stab Detonator Design and Composition



GREEN STAB DETONATOR

New Transfer Charge Candidates:
ENTA
C5NT
5-AZIDO-3-NITRO[1,2,4]-TRIAZOLE, CU
1,5-DIAMINOTETRAZOLE, PERCHLORAMIDES

New Stab mix:
Sol-gel booster coated Nanolaminate
Components: Aluminum, Ferric oxide, titanium, zirconium



Characterization Tests – Friction
SERDP & NSWC Compounds

CODE	CANDIDATE	NO-FIRELEVEL (gms)	MIN. FIRE LEVEL (gms)
$13A_1$	Copper (II) 5-nitrotetrazole	55	65
15A	KBFNP	20	30
17A	5-Azido-3-nitro-[1,2,4]-triazole, Cu *	2075	>2075
17A	5-Azido-3-nitro-[1,2,4]-triazole, Cu #	975	1000
19A	Nitramino-diazido-triazine, Rb	850	900
19A	Nitramino-diazido-triazine, Cs	175	200
28A	1,5-Diaminotetrazole, Cu complex	100	110
28A	1,5-Diaminotetrazole, Fe complex	40	50
29A	DAATO 3.5	2075	>2075
NLS	GY 90022	40	50

Samples were dried at 65ºC for >2 hrs and stored in desiccator until run unless otherwise in
Julius-Peters Small BAM

Characterization Test – Impact
SERDP & NSWC Compounds

CODE	CANDIDATE	IMPACT (J)
$13A_1$	Copper (II) 5-nitrotetrazole	0.057±0.006
15A	KBFNP *	0.009±0.002
17A	5-Azido-3-nitro-[1,2,4]-triazole, Cu *	0.015±0.002
19A	Nitramino-diazido-triazine, Rb *	0.012±0.003
19A	Nitramino-diazido-triazine, Cs *	0.013±0.003
28A	1,5-Diaminotetrazole, Cu complex *	0.011±0.003
28A	1,5-Diaminotetrazole, Fe complex #	0.013±0.002
29A	DAATO 3.5 #	0.085±0.025
NLS	GY 90022	0.025±0.001

* Temp=62ºF RH=32%
# Temp=62ºF RH=49%

Samples were dried at 65ºC for >2 hrs and stored in desiccator until run unless otherwise
Ball Drop Method, Bruceton Analysis

Characterization Test – Strong Ignition (10kpsi Screening)

CODE	CANDIDATE	LOADING PRESSURE (kpsi)	AVERAGE CHARGE DENSITY (g/cm^3)	AVERAGE DENT IN Al BLOCK (mils)
$13A_1$	Copper (II) 5-nitrotetrazole	10	**1.440**	**13.2**
15A	KBFNP	10	**1.626**	**0.8**
17A	5-Azido-3-nitro-[1,2,4]-triazole, Cu	10	**1.421**	**2.3**
19A	Nitramino-diazido-triazine, Rb	10	**1.810**	**0.8**
19A	Nitramino-diazido-triazine, Cs	10	**2.026**	**0.5**
28A	1,5-Diaminotetrazole, Cu complex	10	**1.412**	**16.8**
28A	1,5-Diaminotetrazole, Fe complex	10	**1.465**	**27.0**
29A	DAATO 3.5	10	**1.203**	**0.0**
LA	RD1333, LN 40148	10	**3.119**	**37.3**

Samples were dried at 65ºC for >2 hrs and stored in desiccator until run unless otherwise

Characterization Test – Strong Ignition

CODE	CANDIDATE	LOADING PRESSURE (kpsi)	AVERAGE CHARGE DENSITY (g/cm^3)	AVERAGE DENT IN Al BLOCK (mils)
$13A_1$	Copper (II) 5-nitrotetrazole	5	1.26	9.0
		10	1.38	22.6
		20	1.53	31.7
		40	1.77	29.0
28A	1,5-Diaminotetrazole, Cu complex	5	1.18	25.0
		10	1.33	23.7
		20	1.52	14.7
		40	1.69	7.7
28A	1,5-Diaminotetrazole, Fe complex	5	1.28	35.3
		10	1.40	40.3
		20	1.52	37.7
		40	1.63	23.3
	LA (RD-1333)	5	2.62	27.7
		10	2.99	33.7
		20	3.18	39.0
		40	3.55	46.3

Samples were dried at 65ºC for >2 hrs and stored in desiccator until run unless otherwise indicated

Expected Payoff

- Development of environmentally friendly formulations and manufacturing processes
- Significantly reduce generation and release of toxic materials
- Reduce or eliminate range contaminat
- Positive impact on ammunition life cycle cost

Green Medium Caliber Ammunition

Program Summary

- Environmental issues are numerous and diverse
- Systematic approach developed to address specific issues on DoD wide system level
- Elimination of toxic heavy metals being addressed
- Plan in place to address all contaminants in major ammunition components

Chemical Acronyms/Names

- **(ENTA)**1,1-(N,N-ethylenedinitramino)-3,3,5,5-tetraazidocyclotriphosphazene
- **(C5NT)** Copper(II) 5- nitrotetrazolate
- **(DAHA)** 1,1-diamino-3,3,5,5,7,7-hexaazidocyclotetraphosphazene
- **(RDX) –** Royal Demolition Explosive – cyclotrimethylene-trinitramine
- **(HMX) –** High Melting Explosive – cyclotetramethylene-tetranitramine
- **(CL 20) -** Hexanitrohexaazaisowurtzitane